

Which Element Is Sample X? A Claim-Evidence-Reasoning Case

Learning target: I can use measured atomic mass and observed behavior, together with the patterns of the periodic table, to argue which element an unknown sample is and where it belongs.

Claim, evidence, reasoning

About 40 min

Individual

MS-PS1-1 · practice

writing

data analysis

Standards connections

MS-PS1-1 (practice): Identifying an element from its atomic mass and group behavior exercises the periodic-table reasoning that students will need when they label the atoms in molecular models; it builds toward the PE without producing a model of a molecule.

Purpose: practice · **Time:** about 40 minutes · **Format:** individual

Answers with reasoning

The scenario

A school stockroom has a small sealed jar whose label has worn off. All that remains is 'Sample X' and the words 'keep under oil.' The science technician, Mr. Reyes, cannot throw it out until he knows what it is, because some metals need special disposal. He runs four safe tests and sends a tiny piece to a university lab that can measure the typical mass of the atoms in a sample. His notes are below. The stockroom inventory lists only six metals that were ever ordered, so the sample must be one of those six.

Technician's notes on Sample X — 1. The jar holds a lump of metal stored under oil; the lump floats on the oil. 2. The lump is soft: a steel knife slices it easily. The fresh cut is shiny silver but turns dull gray within a few minutes in air. 3. A rice-grain-sized piece placed in a dish of water fizzes steadily, moves around on the surface and slowly disappears. There is no flame, no spark and no popping. 4. The university lab reports the typical atomic mass as **between 6 and 9 daltons**; their instrument could not be more precise with such a tiny piece.

The six candidate metals (real rounded data)

Element	Symbol	Atomic mass (Da)	Column of the table	Hardness	Behavior in water	Normally stored under oil?
Lithium	Li	7	1	soft, cuts with a knife	fizzes steadily, no flame	yes
Beryllium	Be	9	2	hard, scratches glass	no reaction	no
Sodium	Na	23	1	soft, cuts with a knife	reacts fast; can catch fire	yes
Magnesium	Mg	24	2	fairly hard	almost no reaction in cold water	no
Potassium	K	39	1	very soft	bursts into flame immediately	yes
Calcium	Ca	40	2	fairly hard	fizzes steadily	no

Warm-up: organize the evidence

1. Using only note 4 (the atomic mass range), which candidates are still possible? Which are ruled out?

Answer: Still possible: lithium (7 Da) and beryllium (9 Da). Ruled out: sodium (23), magnesium (24), potassium (39) and calcium (40), because their masses are far above 9 Da.

Why: The 6-9 Da range includes 7 and 9 only.

Also acceptable: None.

2. Of the candidates left after q1, which notes rule out all but one? Name the note numbers and explain what each one eliminates.

Answer: Note 2 (soft, cuts with a knife) rules out beryllium, which is hard enough to scratch glass. Note 3 (fizzes in water) also rules out beryllium, which does not react with water. Note 1 (stored under oil) points the same way, since beryllium is not stored under oil. That leaves lithium.

Why: Any one of notes 1, 2 or 3 is enough to eliminate beryllium; the strongest answers cite two or three.

Also acceptable: Accept any combination of notes 1, 2 and 3 with correct reasons.

- Names at least one note that eliminates beryllium with the correct reason
- Concludes lithium remains

3. Note 3 says the sample fizzed with no flame. Explain why this single observation is enough to rule out sodium and potassium even without the mass measurement.

Answer: In the table, sodium reacts fast and can catch fire and potassium bursts into flame immediately. A steady fizz with no flame does not match either, so both are ruled out by behavior alone. Lithium and calcium are the only candidates that fizz steadily.

Why: This question shows students that behavior evidence can do work that mass evidence also does, which is why combining them is powerful.

Also acceptable: A student who adds that calcium would also fit note 3 but is too heavy and too hard is reasoning well.

- Cites the flame behavior of sodium and potassium from the table
- Explains the mismatch with 'no flame'

Your argument

Answer: Claim: Sample X is lithium (Li), and it belongs in column 1 of the periodic table with sodium and potassium. Evidence: (1) The measured atomic mass is 6-9 Da, which fits only lithium (7) and beryllium (9) and rules out sodium, magnesium, potassium and calcium (23-40 Da). (2) The lump is soft enough to slice with a knife; beryllium is hard enough to scratch glass. (3) The sample fizzes steadily in water with no flame; beryllium does not react, and sodium and potassium would flame. (4) It is stored under oil and floats on the oil; of the six, only the column-1 metals are kept under oil. Reasoning: Elements in the same column behave alike, so the behavior pattern (soft metal, kept under oil, reacts with water) places Sample X in column 1 with sodium and potassium. Within that column the reaction gets more violent with increasing mass (lithium fizzes, sodium can flame, potassium bursts into flame), so a gentle fizz plus a very low mass both point to the lightest member, lithium. The mass alone could not separate lithium from beryllium, and the behavior alone could not separate lithium from calcium, so both kinds of evidence were needed to reach a single answer.

Why: This is the solved model response. Full credit requires a specific claim (element and column), at least three evidence items with numbers or observations and what each rules out, and reasoning that invokes the same-column pattern and explains why mass and behavior were both necessary.

Also acceptable: A student who claims lithium but places it in 'the column with sodium and potassium' without the number 1 is correct. A student who argues for calcium has ignored the mass range and the hardness; that response can earn partial credit for evidence organization but not for the claim.

- Claim names lithium and column 1
- At least three evidence items tied to notes or table values
- Each evidence item says which candidates it eliminates
- Reasoning uses the pattern that elements in a column behave alike
- Reasoning explains why mass and behavior together were needed

4. Mr. Reyes could ask the university lab to repeat the mass measurement with a larger piece. Would a more precise mass change your claim? Explain what result would **confirm** your claim and what result would **force you to change** it.

Answer: A more precise mass would not change the claim but could strengthen it. A result close to 7 Da would confirm lithium. A result close to 9 Da would conflict with the behavior evidence (beryllium is hard and does not react with water), so the student would have to question either the measurement or the observations, and a result near 23 or 40 Da would force a complete rethink and suggest the lab mixed up samples.

Why: The point is that claims should be revisable and that students can state in advance what would confirm or overturn them.

Also acceptable: Accept 'a result of 9 Da would mean something is wrong with the notes' as a disconfirming result.

- States a confirming result (near 7 Da)
- States a result that would force a change, and what the student would do about it

Scoring rubric

Criterion	4 • Exemplary	3 • Proficient	2 • Developing	1 • Beginning
Claim	Names lithium and its column (column 1, with sodium and potassium) in one clear statement.	Names lithium; the column is missing or vaguely described.	Names a column-1 metal other than lithium, or names lithium with contradictory statements.	No claim, or a claim unrelated to the evidence.
Evidence	Three or more specific pieces of evidence with numbers or observations, each stating which candidates it rules out.	Three pieces of evidence, but one lacks a number or does not say what it rules out.	One or two pieces of evidence, or evidence copied without connecting it to candidates.	Evidence is missing, invented, or contradicts the notes.
Reasoning	Uses the same-column pattern explicitly, explains the trend within column 1, and explains why both mass and behavior evidence were needed.	Uses the same-column pattern and connects evidence to the claim, but does not explain why both kinds of evidence were needed.	Restates the evidence without a pattern, or states the pattern without linking it to the claim.	No reasoning, or reasoning that misuses the table (for example, treating a row as a group).
Scientific language and accuracy	Uses atomic mass, column or group, element and daltons correctly; no scientific errors.	Terms mostly correct; one minor slip (for example, 'weight' for mass).	Several terms used loosely or interchangeably (atom for element, row for column).	Scientific language absent or consistently wrong.

Teacher notes

All candidate data are real: lithium floats on mineral oil (density about 0.53 g per cm³), is cut easily, tarnishes quickly in air and reacts with water with a steady fizz and no flame; beryllium is hard and inert in water; sodium can ignite; potassium ignites immediately; calcium fizzes steadily in water. Do not demonstrate any alkali metal in water with this sheet; it is a paper case. The mass range 6-9 Da is a deliberate design choice so that mass alone cannot settle the question and students must combine two

kinds of evidence. If a student asks why the lab gives a range, say that very small samples give less precise results.

Scaffold offered to students: Evidence table before writing

On scrap paper, make a grid with the six candidates across the top and the four notes down the side. For each note, cross out every candidate it rules out and write the reason in two or three words (for example, 'too heavy', 'not soft', 'would catch fire'). The one column with no crosses is your claim, and each cross you wrote is a piece of evidence you can copy into your CER.

Extension: A seventh candidate

Suppose the inventory also listed rubidium (Rb, 85.5 Da, column 1, very soft, stored under oil, explodes on contact with water). Rewrite your Evidence section so that it rules rubidium out, and then explain, using the column-1 pattern from lithium to potassium, why rubidium's reaction with water is expected to be even more violent than potassium's, even though no note describes it.